AEROGEL CHERENKOV COUNTER

PHENIX Focus

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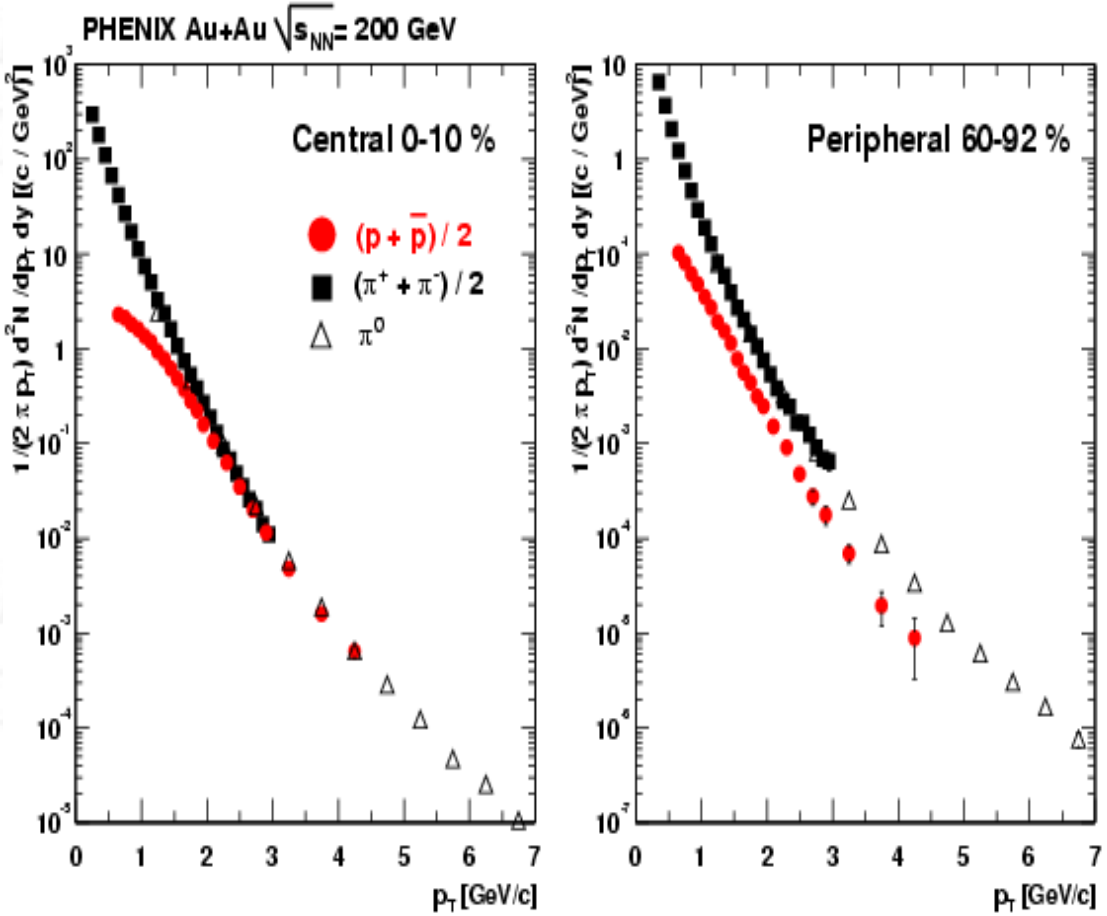
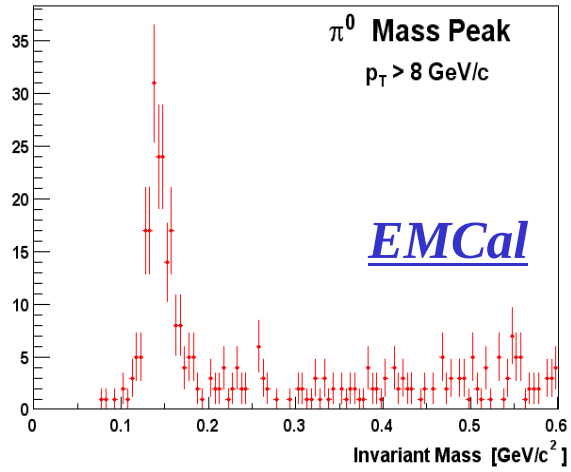
For the High-p_T Upgrade Team

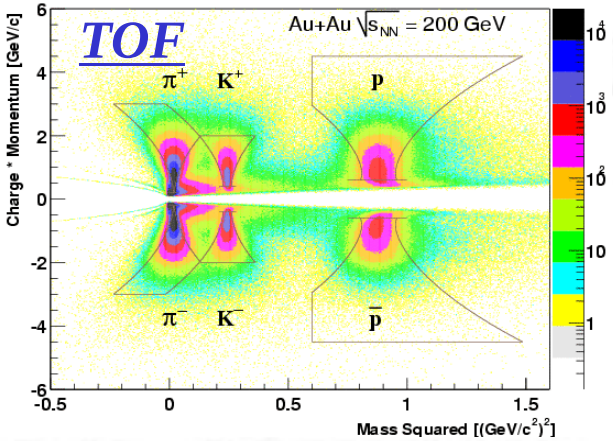
Contents

- Concept
- What is PHENIX Aerogel Cherenkov Counter?
- Mechanical design & Electronics
- Simulation Activity
- Performance of single cell
- Results & Future Plan
- Summary

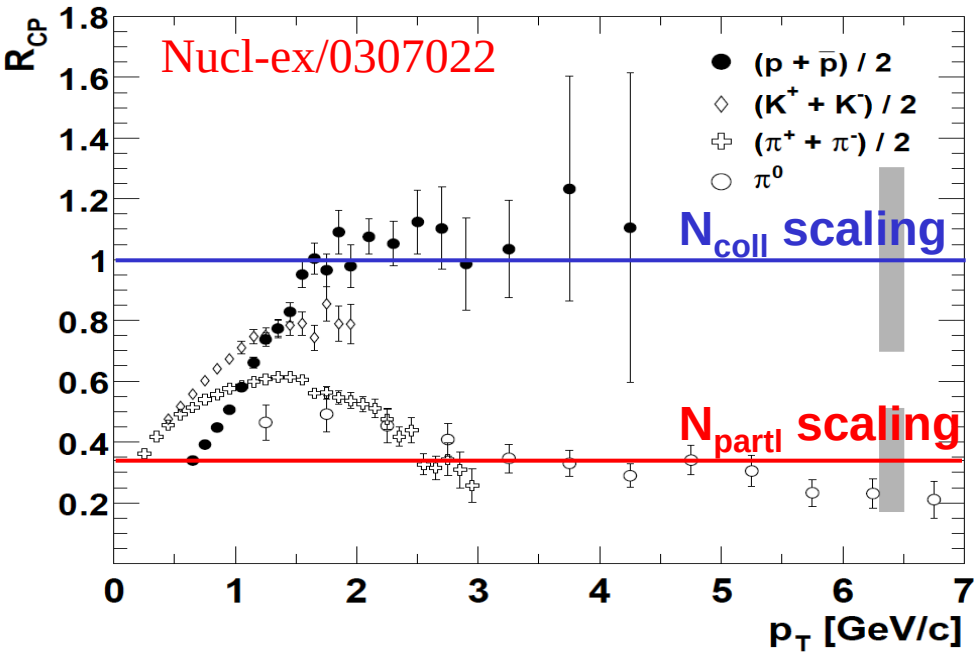
Currently, PID is …







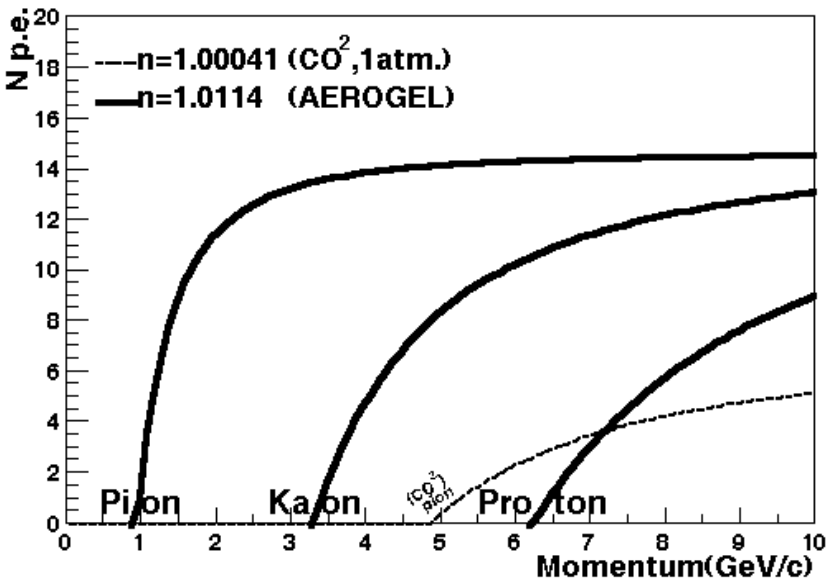
Physics Motivations



- ✓ From basic strategy, it is natural extension for PHENIX to extend its PID in higher pt region.
- ✓ Strong motivation given;
  - Jet Quenching !?
  - Large suppression of pions at high-pT, while protons show binary scaling!?
    - Meson/baryon puzzle?
    - Need to extend PID > 5GeV/c !!

Concept

- PID in high p_T region
  - Cherenkov Radiation
- Cherenkov Radiator
  - Low refractive index
  - Best index with RICH(CO_2) is n ~ 1.01.

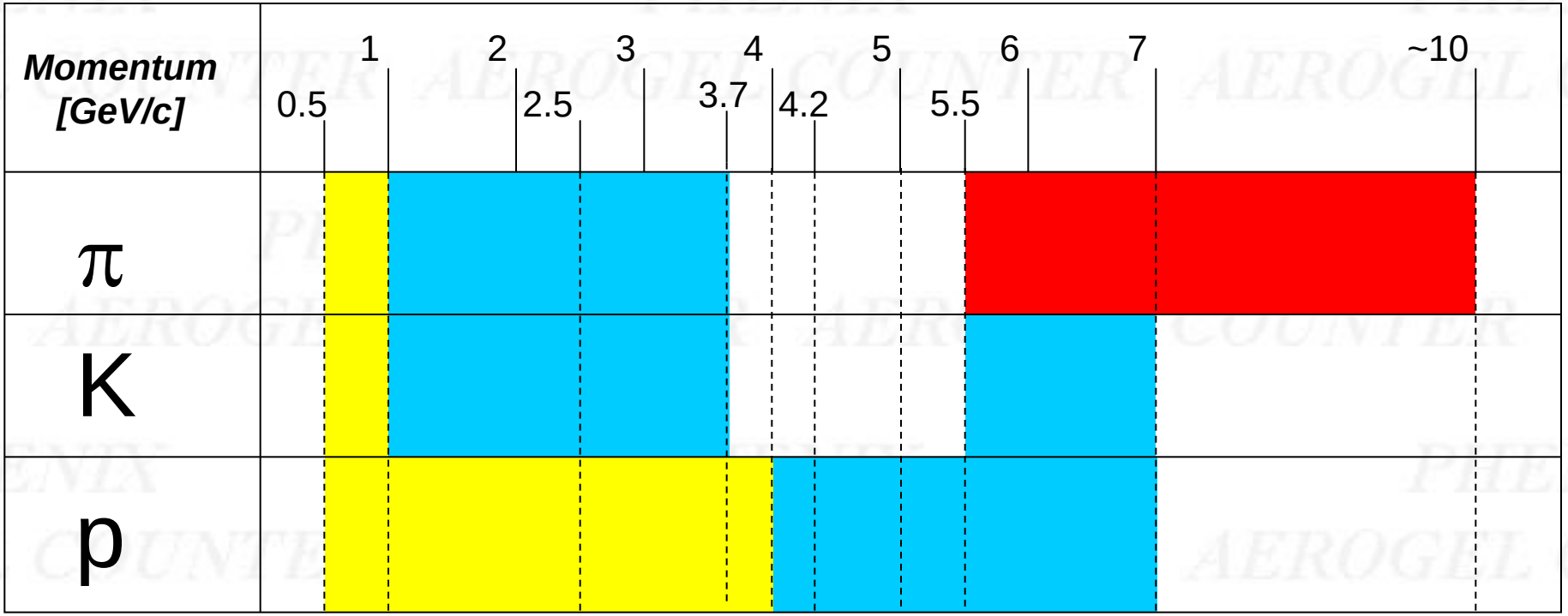


Requirements

- Refractive index : n~1.01 – Momentum threshold
- Light yield : >10 p.e. – Resolving power
- Uniformity of the light yield : Needed. – Easy handling
- Occupancy in Au+Au collisions : <10% – S/N

Installation Purpose

- To enhance the PID capability of PHENIX !!

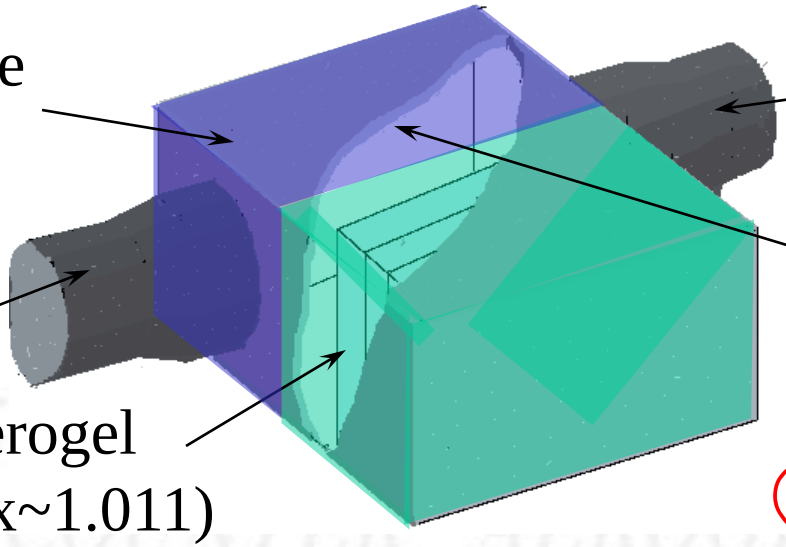


Aerogel : (n=1.011)
TOF : 100 ps time resolution
RICH : CO_2, (n = 1.00041)

What is Aerogel Counter ??

(I) Outline

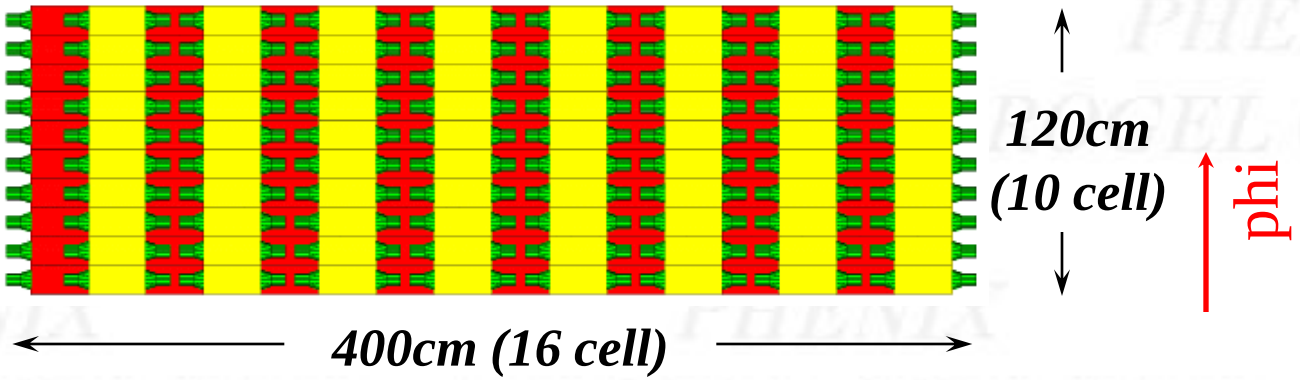
- Cherenkov Counter (non-ring-imaging type)
  - Cherenkov radiator is Silica Aerogel. (MATSUSHITA, SP-12M)
  - Photon is detected by 2 PMTs. (HAMAMATSU, R6233)
  - All inner surface is covered with DRP Reflector. (Goretex)
  - Integration cube for uniformity of light yield. (Air)



What is Aerogel Counter ??

(II) Aerogel Panel

~ Side view ~



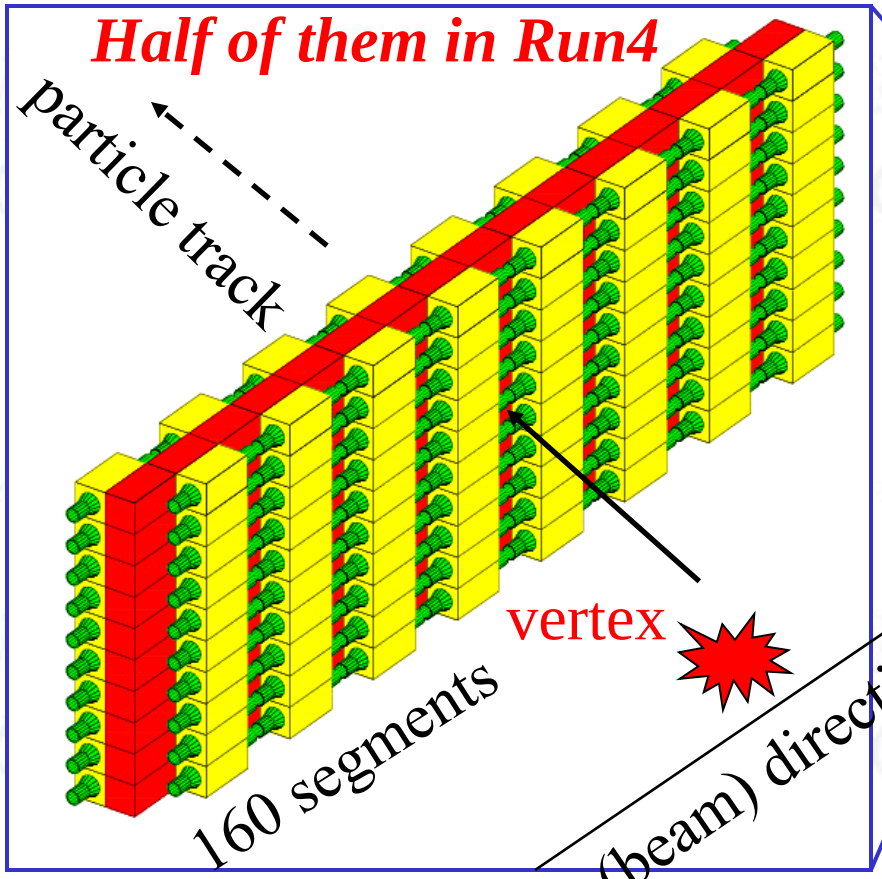
~ Top view ~

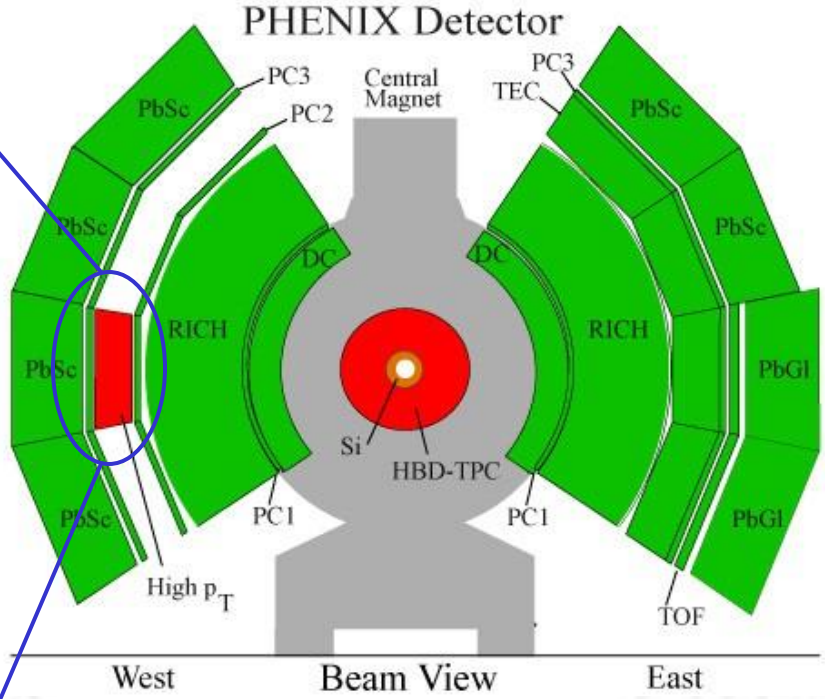
✓ *Direction of each other cell is reversed*

- Aerogel locates at the same distance from vertex.

What is Aerogel Counter ??

(III) Where





- 4.5m from vertex
- 4.0m along z direction
- 15 deg. in phi

RED: Aerogel
YELLOW: Integration sphere
GREEN: PMT

Mechanical Design

(I) Silica Aerogel

- Characteristic
  - Refractive index ~ 1.0114 +/- 0.0008
    - Silica aerogel with lowest refractive index commercially available !!
  - Density ~ 40 mg/cm^3
  - Transparent for 10mm thickness
    - 64% @ 400nm, 88% @ 550nm
  - Hydrophobic
  - Long term stability (KEK-Belle)
  - Very fragile

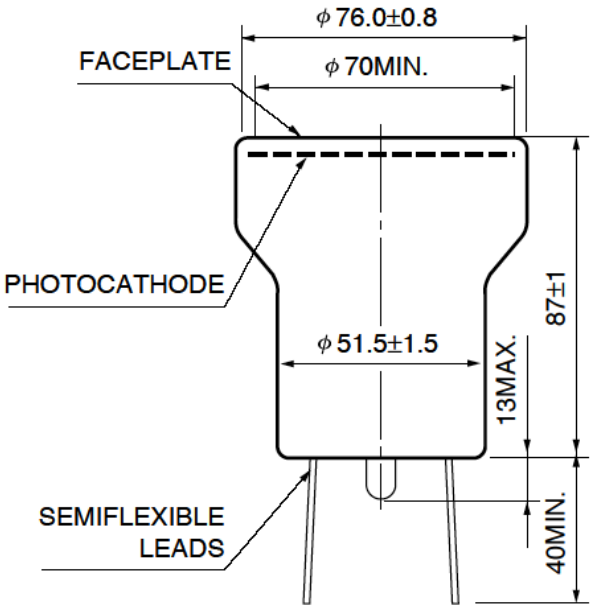
Many many Aerogel tiles!!

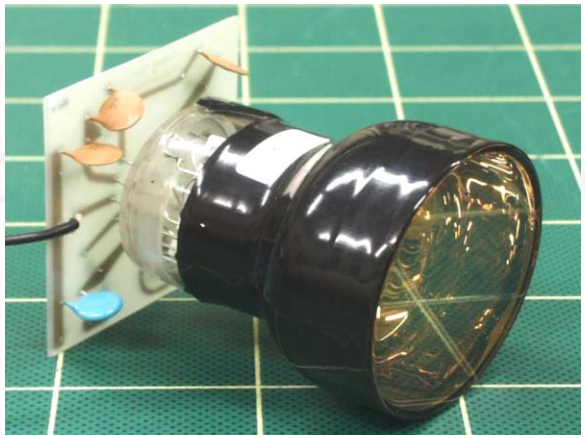
Y.Miake

He is godfather of aerogel !!

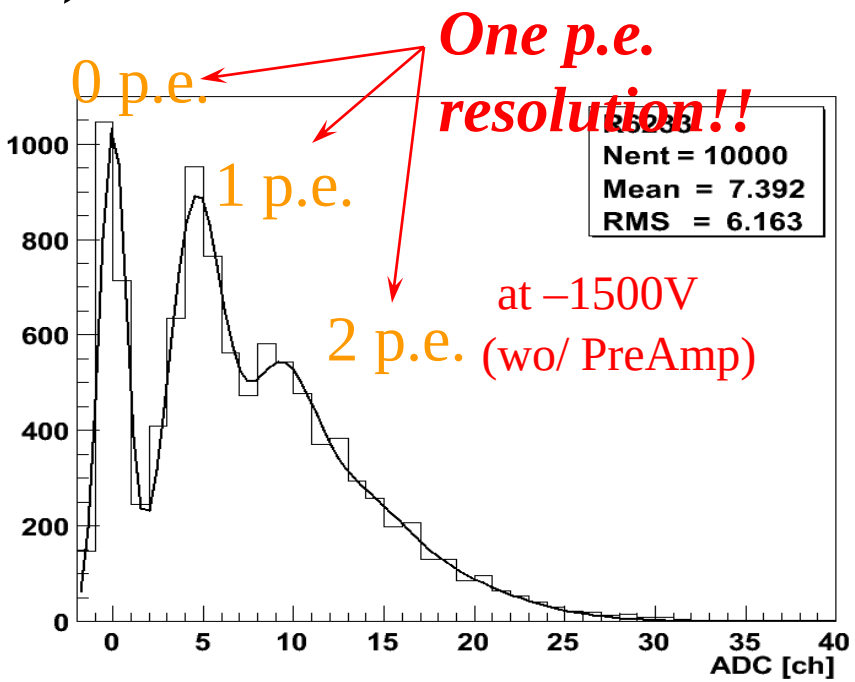
Mechanical Design

(II) PMT





PMT R6233-01HA (HAMAMATSU)

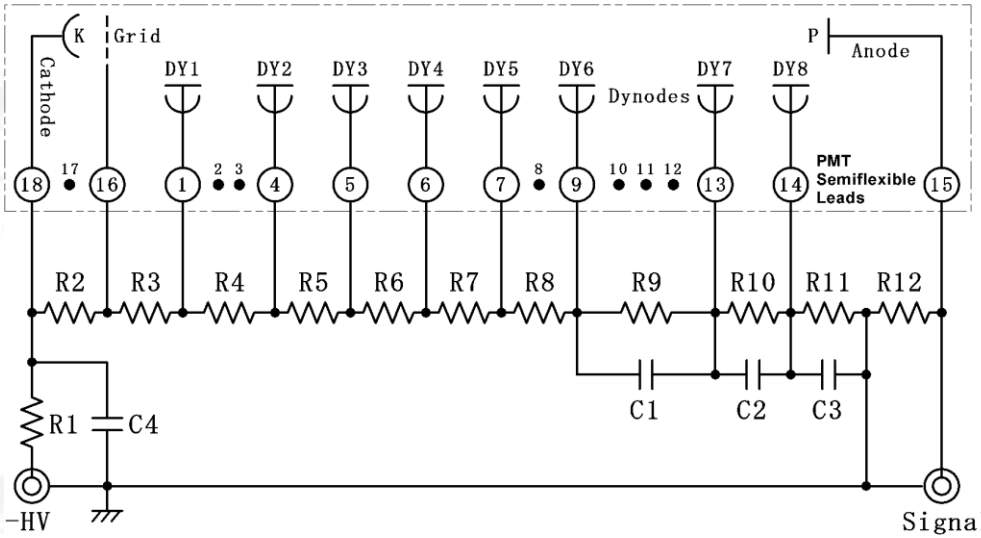


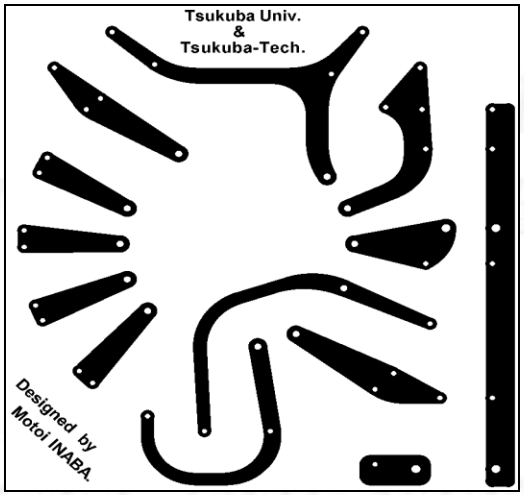
PMT R6233-01HA (HAMAMATSU)
- 3-inch diameter ***large !!***
- Gain : >10^7 at –1500V ***high gain !!***
- Q.E. : 30 % ***high Q.E. !!***
- Dark Current : 2nA ***low noise !!***

Mechanical Design

(III) HV Divider for PMT

- High Gain compared with HAMAMATSU standard
  - Voltage distribution ratio was modified from standard.
- Low Power consumption
  - We do not need cooling.
- Hand made
  - For Thinner material & less space





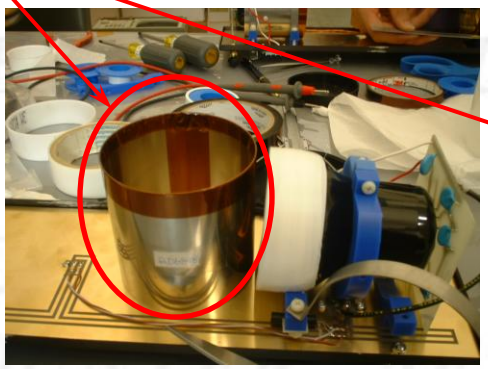
Mechanical Design

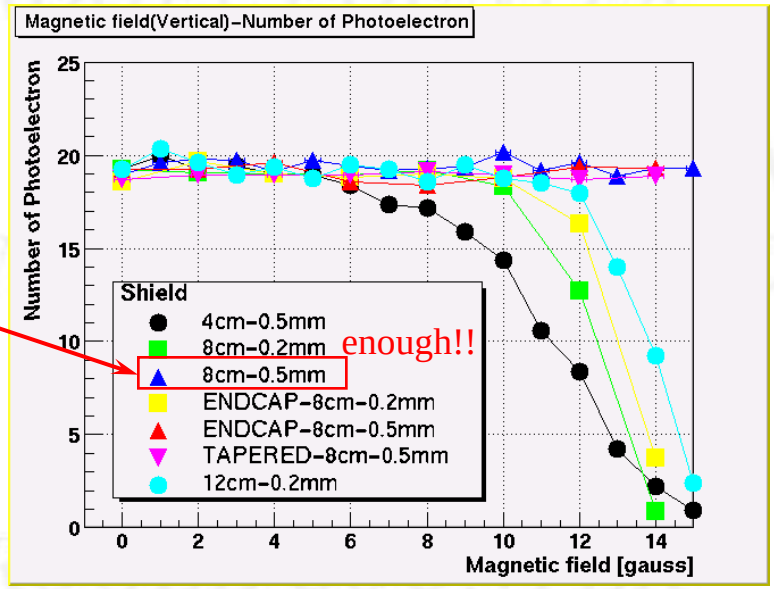
(IV) Mu-metal Shield

- Magnetic field (W1 sector)
  - B-field at the place where the aerogel counters is installed : 2~8 Gauss

- Mu-metal Shield
  - Thickness & Size of the mu-metal shield has been optimized.

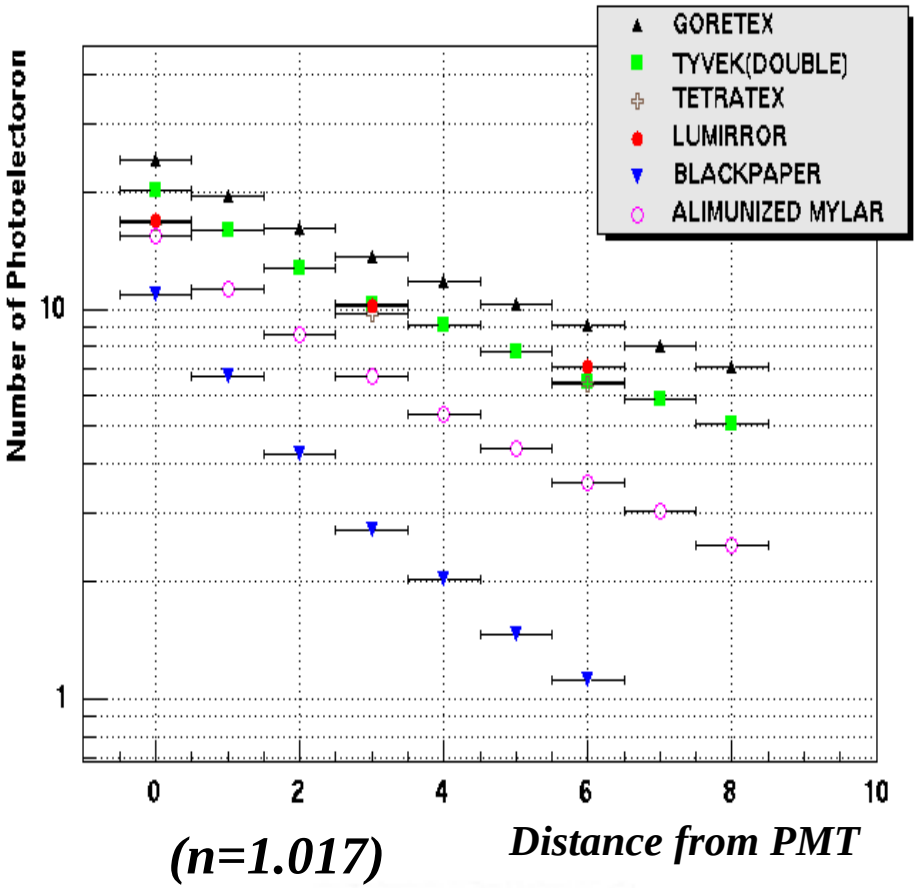
    - 0.5mm thick, 80mm long is enough !!





Mechanical Design

(V) Reflector Selection



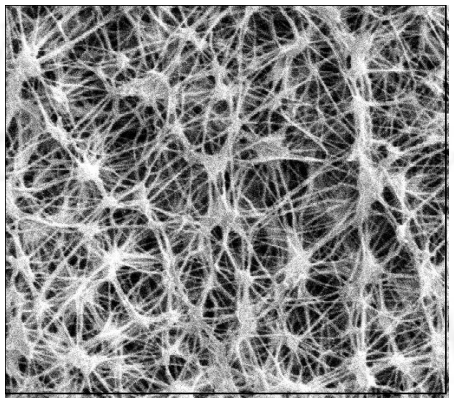
(n=1.017)

Reflector	$N_{p.e.}$	Attenuation Length [cm]
Goretex	11.78	6.5±0.3
Lumirror	10.2	6.9±0.4
Tetratex	9.8	6.3±0.4
Tyvek (Double)	9.1	5.8±0.2
Aluminized Mylar	5.3	4.4±0.2
BlackPaper	2.0	2.6±0.1

Goretex is the best!!

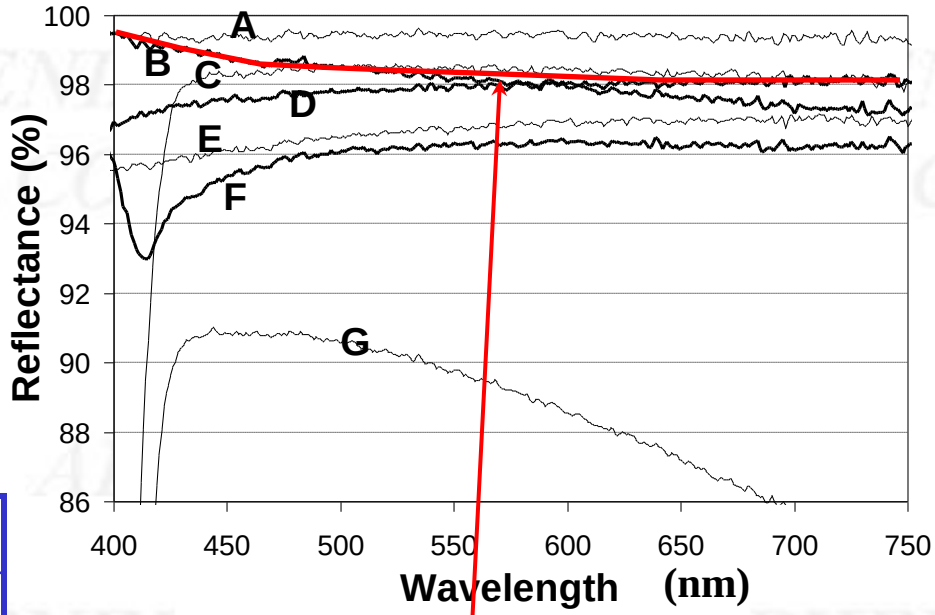
Mechanical Design

(VI) Reflector Property



5000x SEM of DRP®Reflector

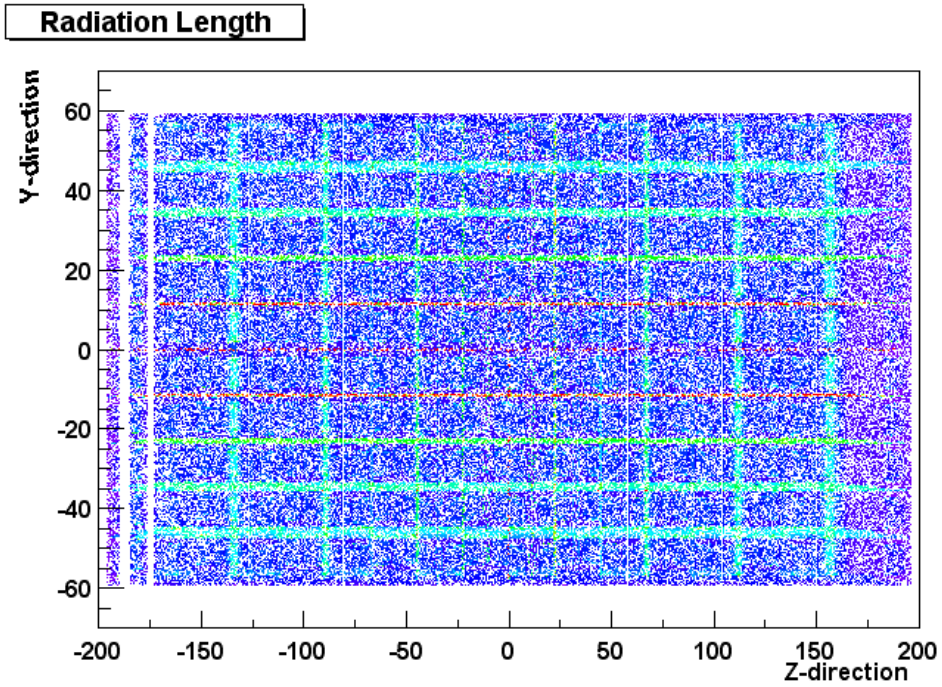
Thickness	0.5 mm
Thermal conductivity	0.04 W/m/K
Water resistance	Highly hydrophobic
UV Exposure	UV-resistant
Dimensional shrinkage	< 1%
Durability	Inert, stable
Reflectance	> 98%

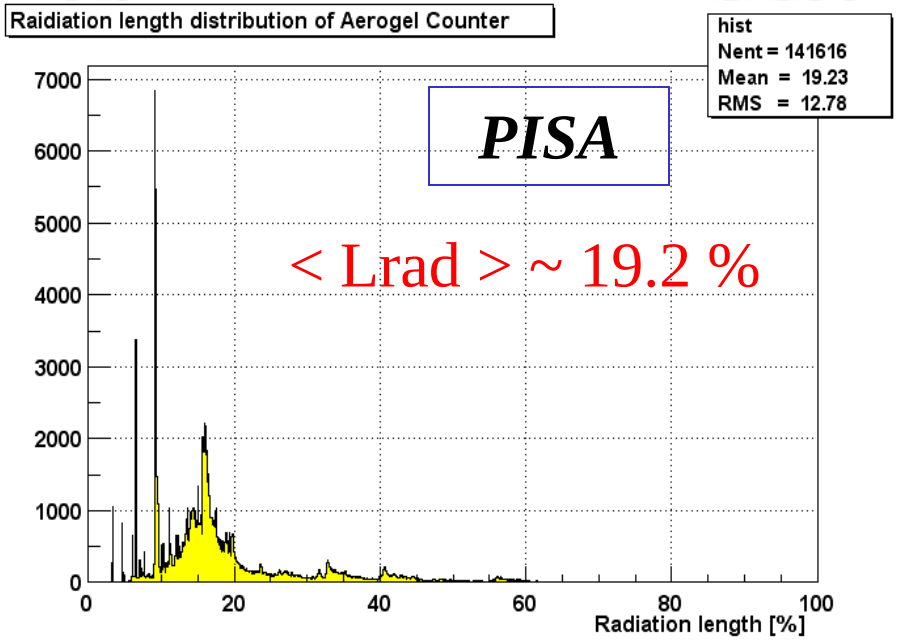


A	3.0 mm DRP® Reflector
B	0.5 mm DRP® Reflector
C	0.25 mm DRP® Reflector
D	Granular PTFE
E	Barium Sulfate
F	Microporous Polyester
G	Powder Coating

Mechanical Design

(VII) Radiation Length



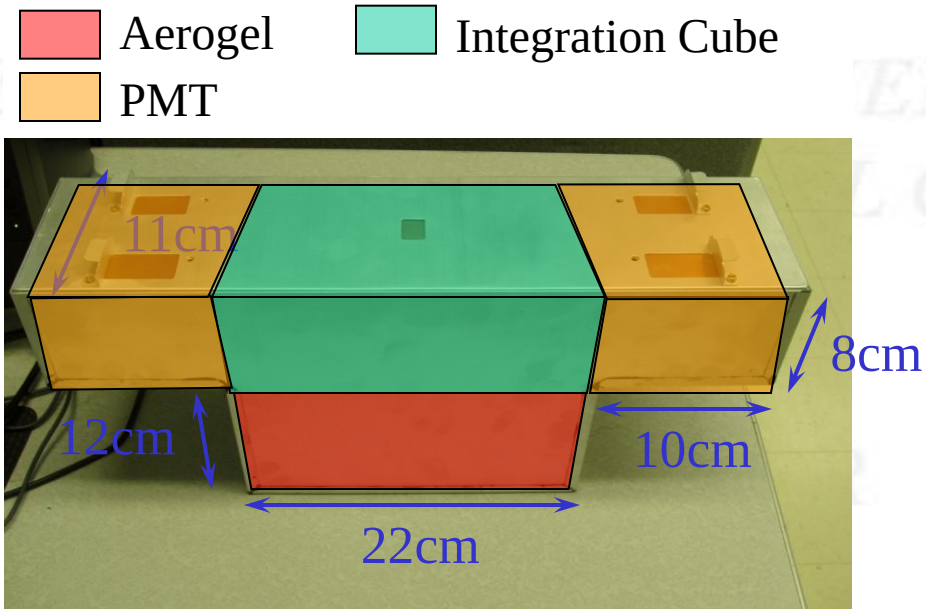


- ✓ Overall radiation length is about 19.2% !!
  - It is similar to TOF. (TOF ~ 18.7%)

Mechanical Design

(VIII) Aluminum Box

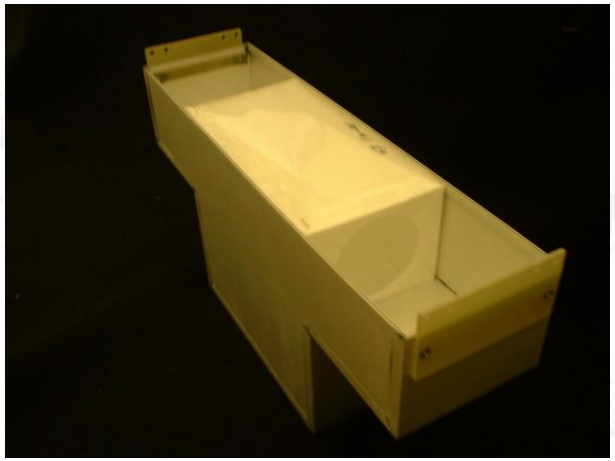
Box Production @ Dubna

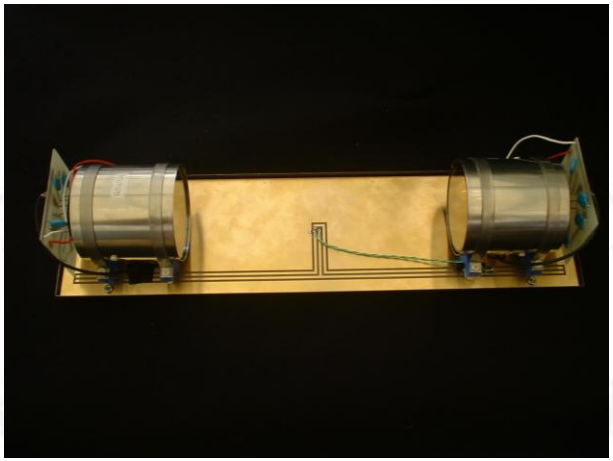


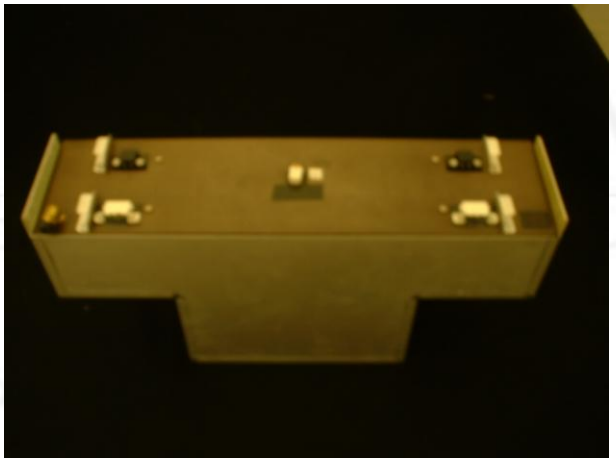
Fabricated Box

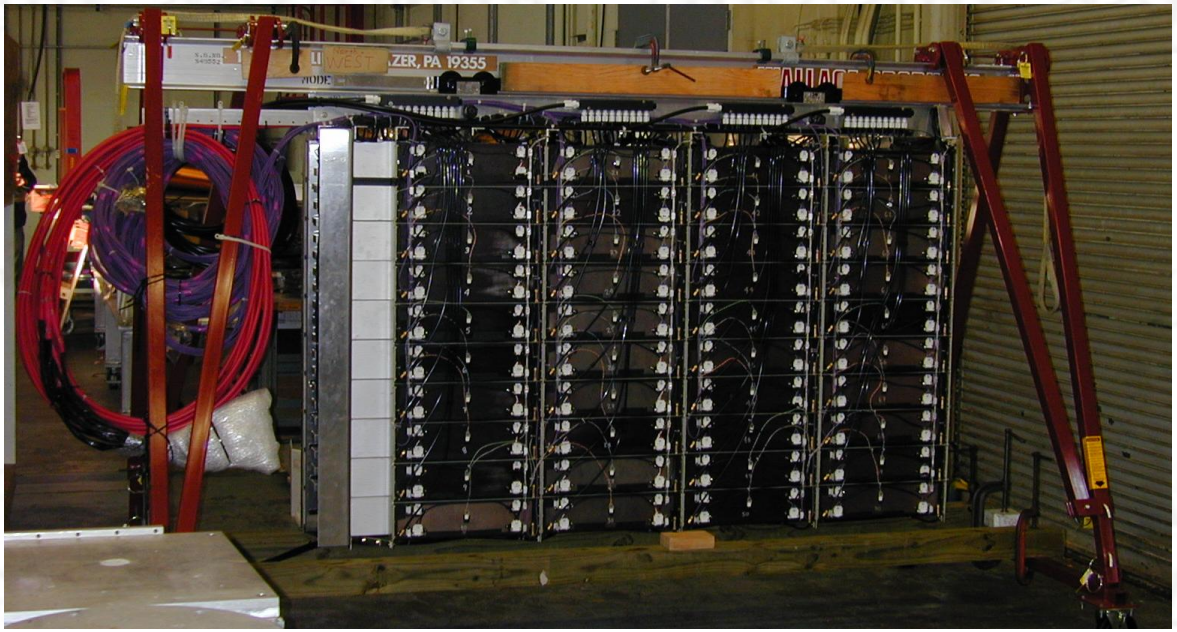
- ✓ Aluminum Boxes were made in Dubna !!!
  - Thickness of Lid : 0.8 mm
  - Thickness of other parts : 0.5 mm

Assembled Counter





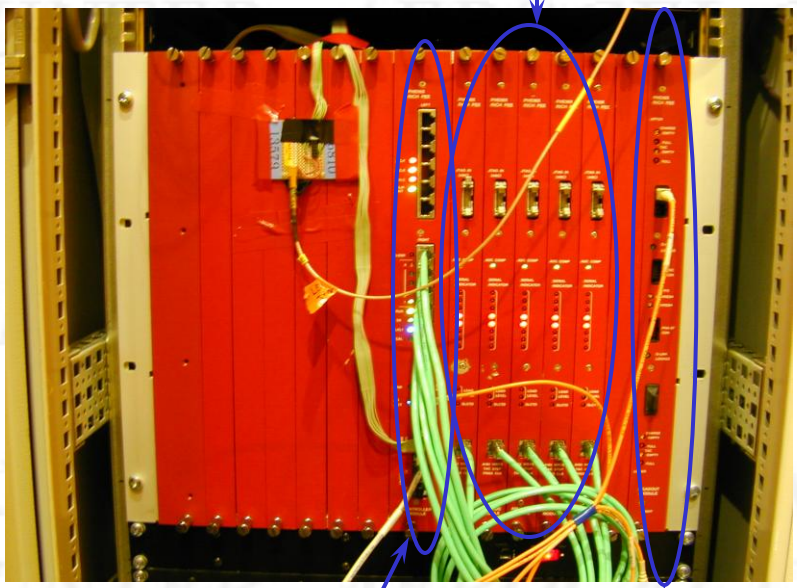




Electronics

(I) Front End Electronics

- ✓ ACC-FEE is the same as the RICH one, except for the trigger module.
  - 1 controller board, 5 AMU/ADC board 1 readout board
- ✓ Read out signal from 160 PMTs
  - 0 to 50 p.e. detection with 10 bit
- ✓ AMU/ADC module
  - 64 channels for Analog to Digital Converter.
  - Charge and Timing information is digitized on AMU/ADC module.



ACC-FEE
(ACC : Aerogel Cherenkov Counter)

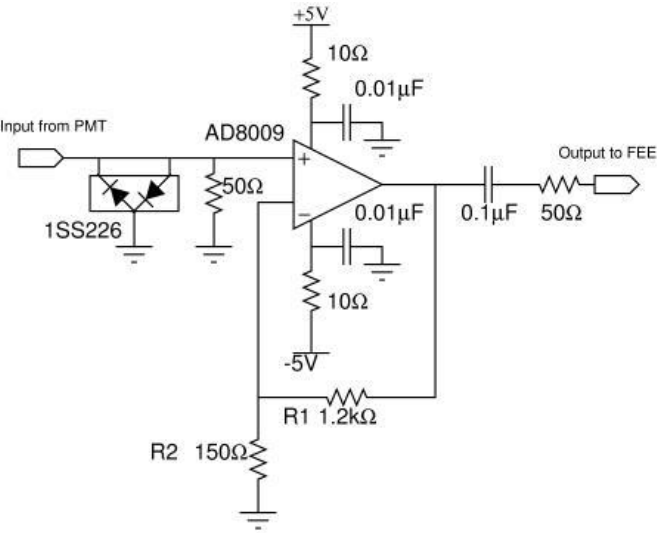
Electronics
(II) Preamplifier

➢ Preamplifier Gain

- PMT signal : 0.8 pC/p.e.
- FEE dynamic range : 0 to 160 pC

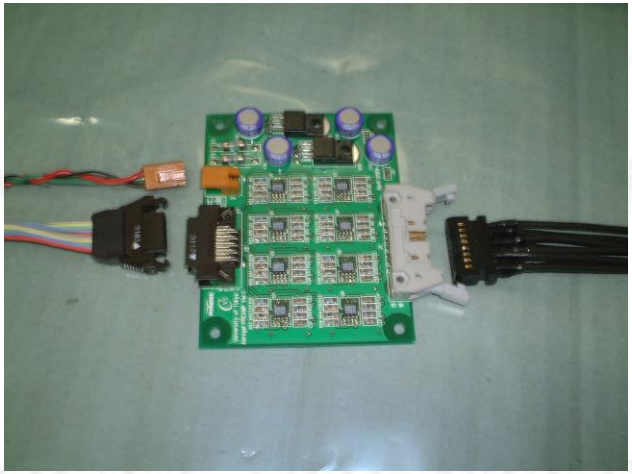
To measure the photo-electrons at the range from 0 to 50 p.e. (0 to 40 pC)

⇒ Required Preamp's net gain : x 4



➢ Performance

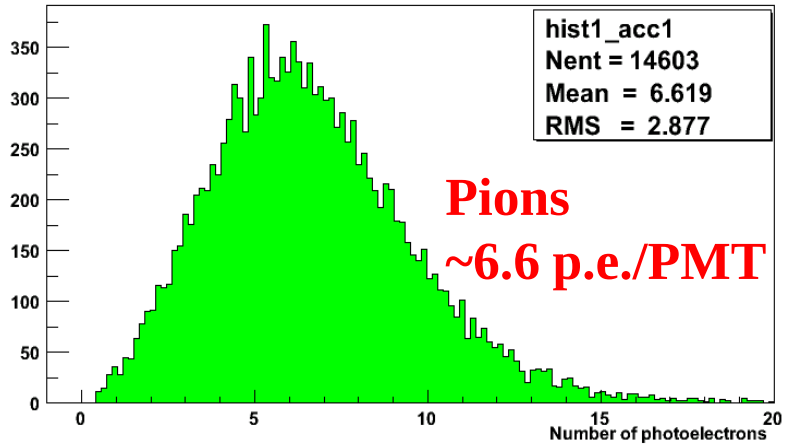
- The measured gain is 4.3.
  (design value is 4.5.)

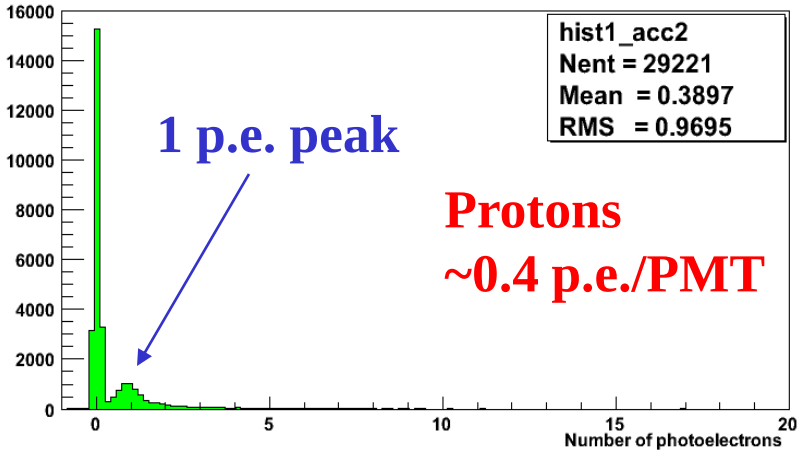


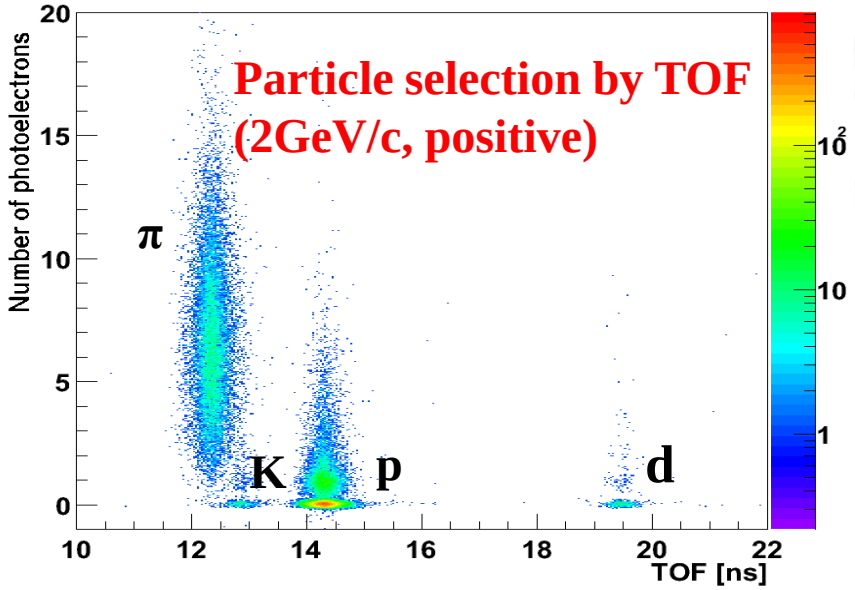
Performance of Single Cell

(I) Clean Signal

Test Beam (KEK-PS)





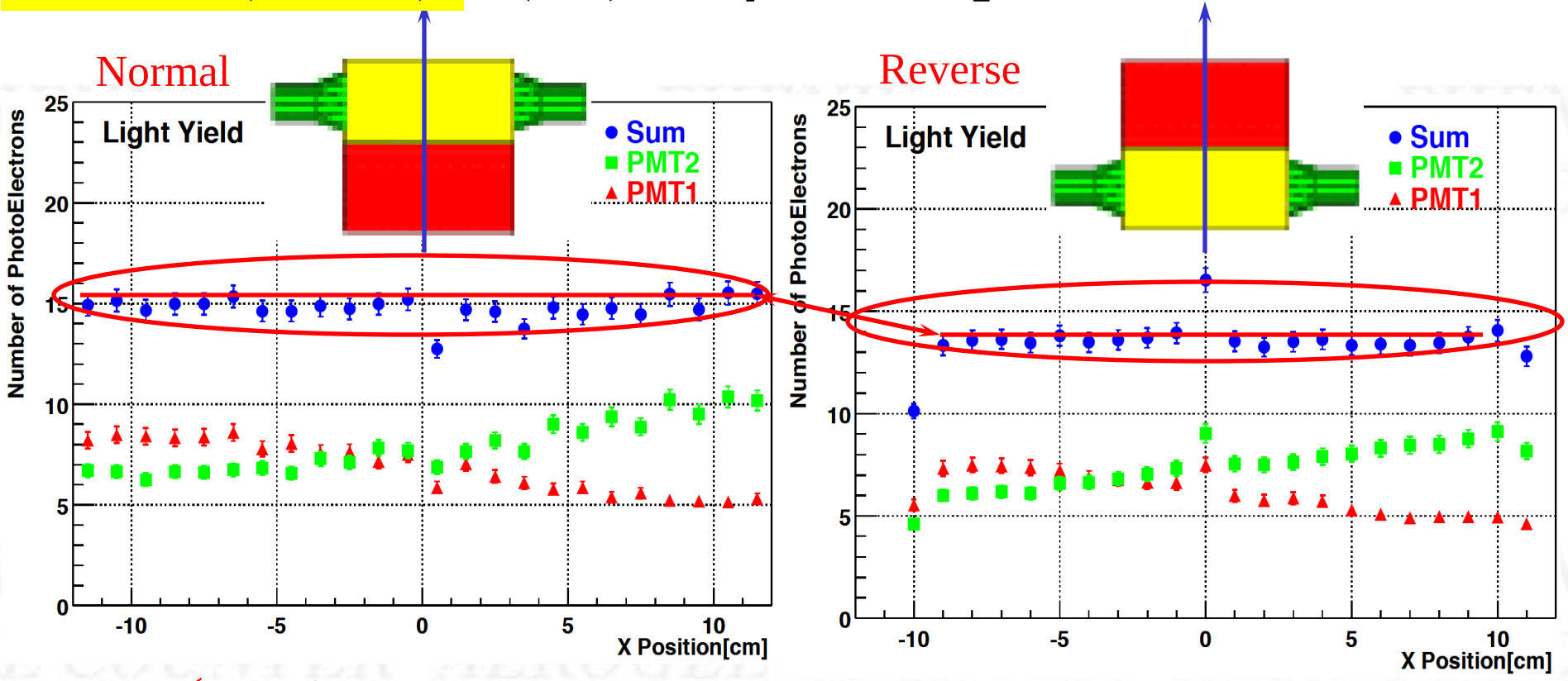


- ✓ Very clean separation !!
- ✓ Amount of photons other than Areogel Cherenkov is small !!

Performance of Single Cell

(II) Uniform Response

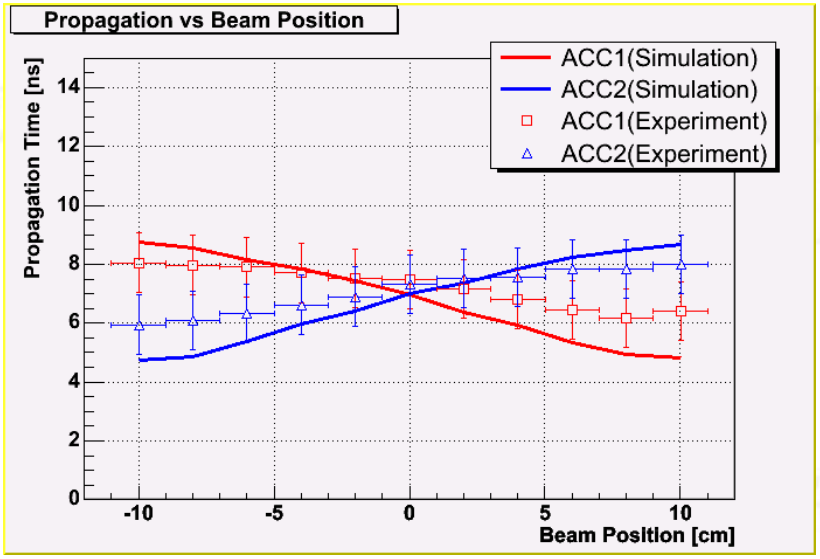
Test Beam (KEK-PS)

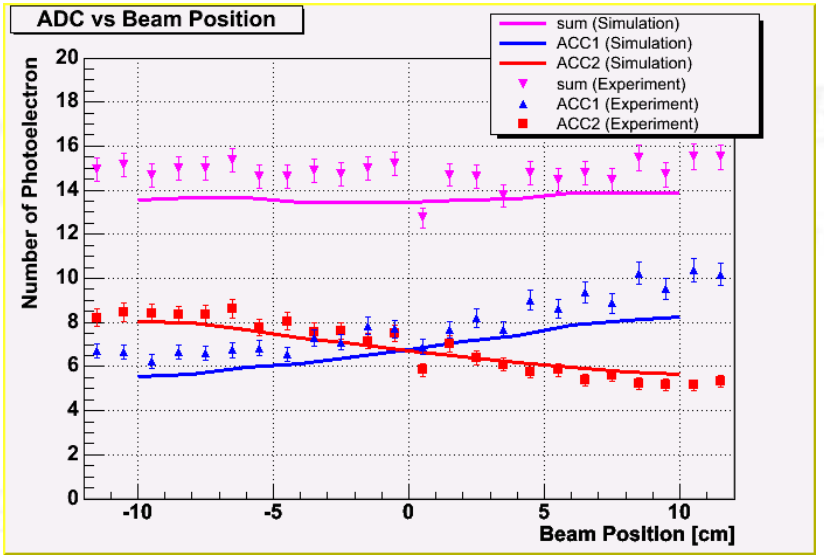


- ✓ Uniform response, thanks to Integration Volume
  - Important to separate in the momentum region of slow rise
- ✓ ~10% diff. between normal/reverse, due to diffusive nature of aerogel

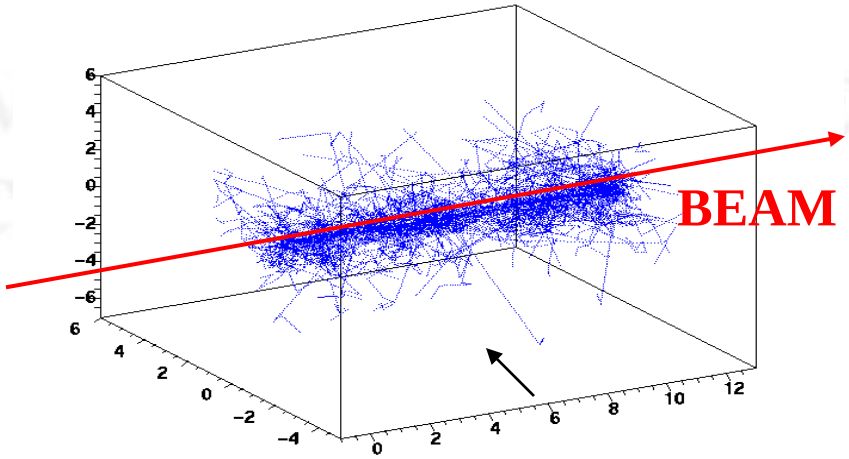
Simulation Activity

(I) Optical Simulation





	Sim.	Exp.
Np.e.	~ 14 p.e	~ 15p.e.
Propagation	~ 7 ns	~ 7 ns
Time diff.	~ 4ns (max)	~ 2 ns (max)

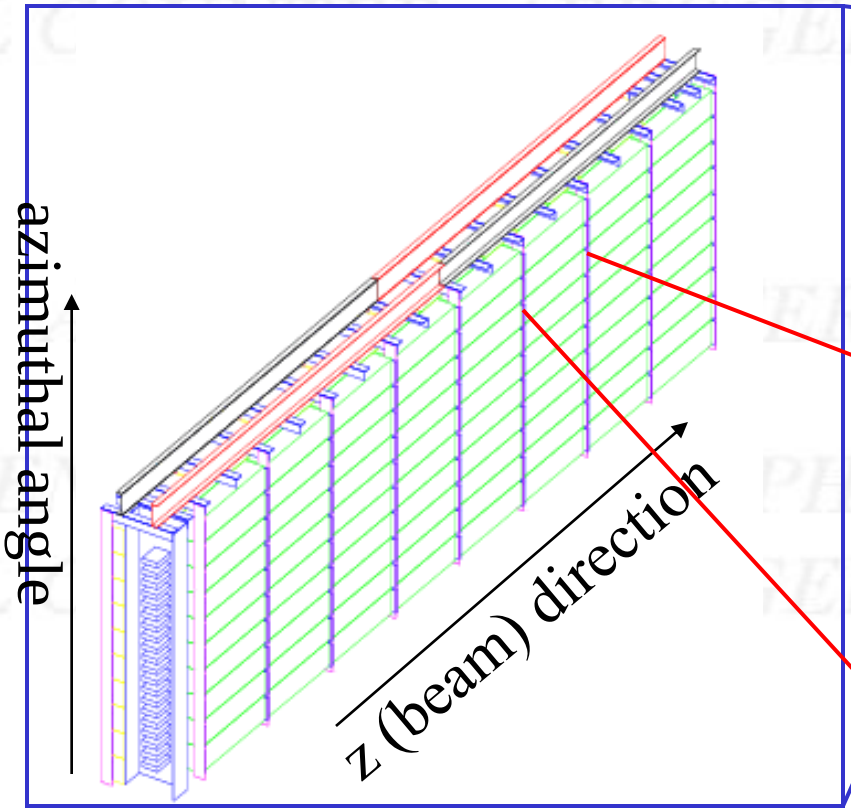


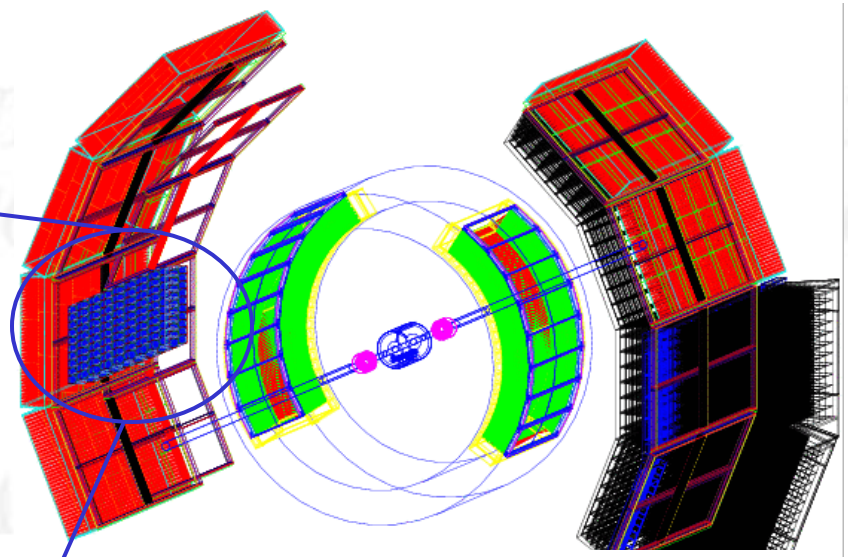
Photon Propagation

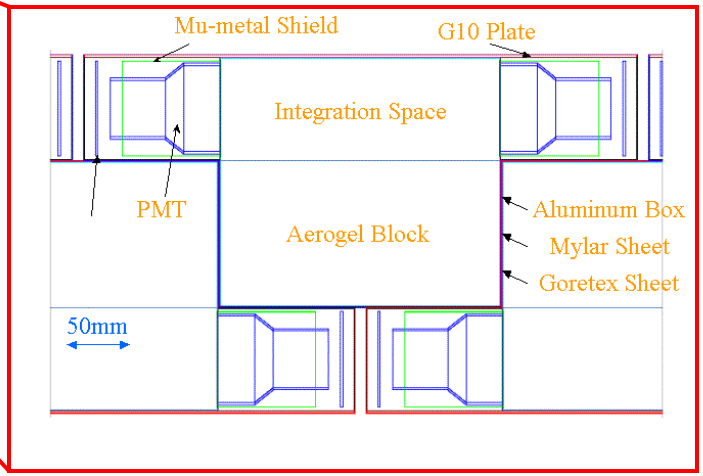
Simulation Activity

(II) Aerogel Cherenkov Counter in PISA

Almost material put into PISA !!







Online Monitoring

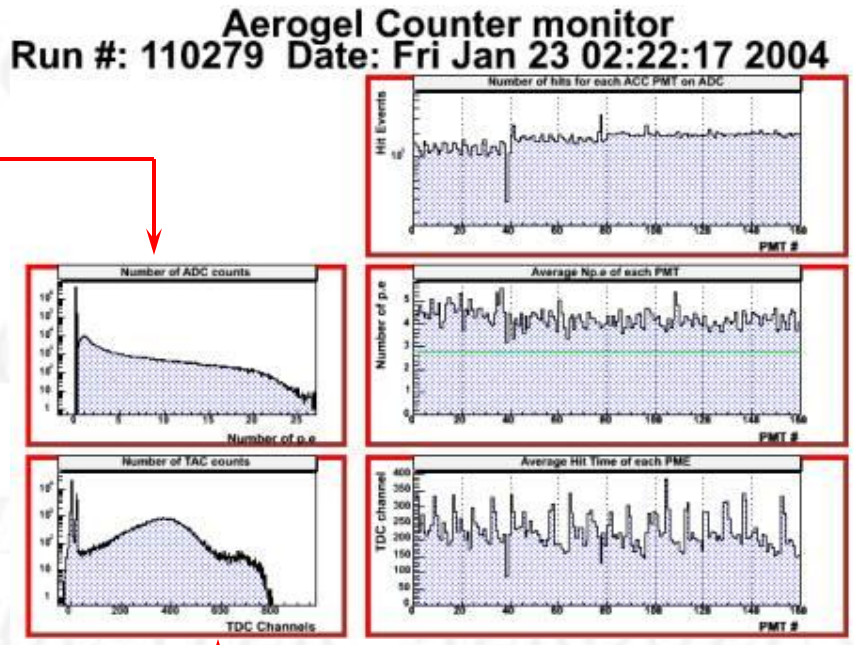
(I) Information of the Summed PMTs

Charge distribution

- Convert ADC to number of p.e.
- The sum of p.e. in all PMTs. (160 PMTs).

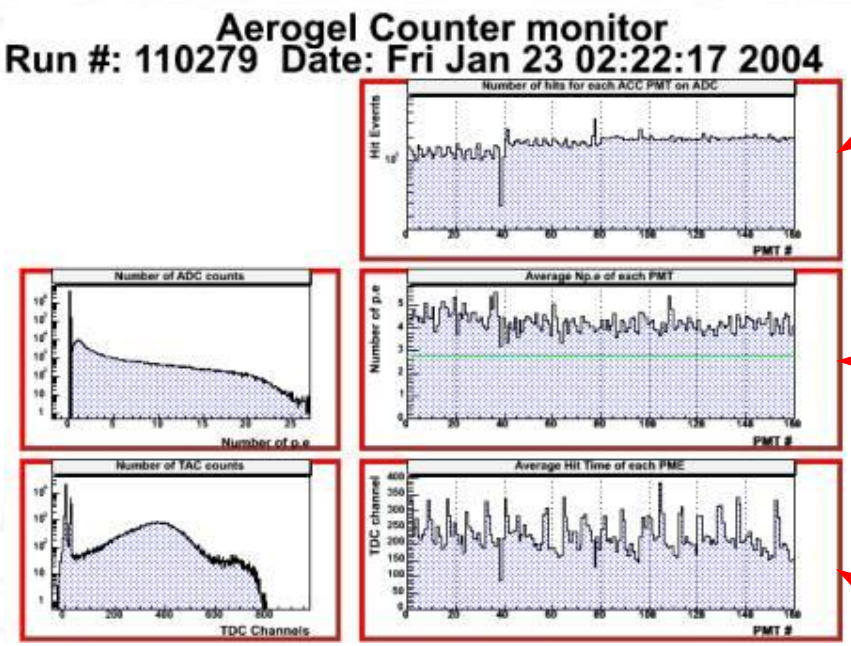
Time distribution

- The time distribution of ACC in all PMTs(160 PMTs)



Online monitoring

(II) Information of each PMT



Hit information

- Number of hits for each PMT

Number of p.e.

- Number of mean p.e for each PMT

Time information

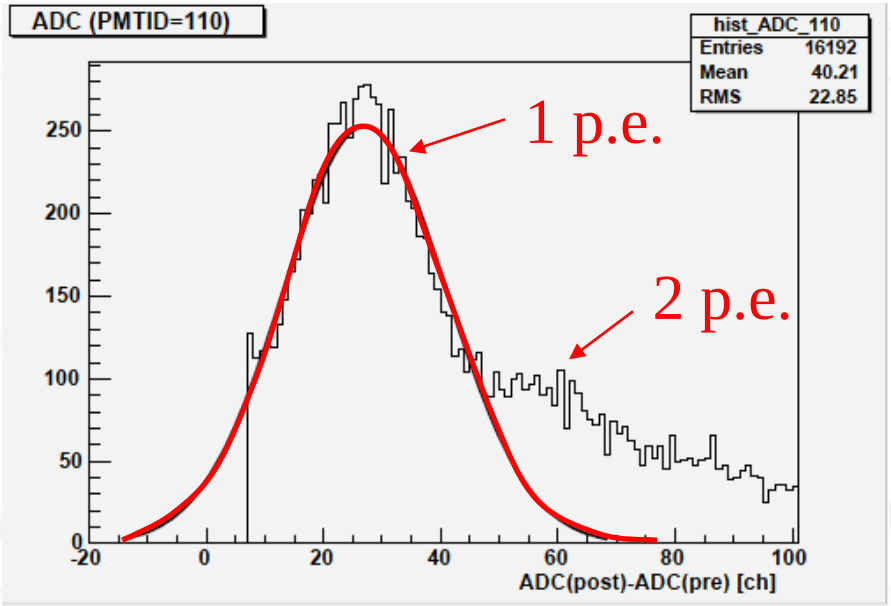
- Mean TAC Value for each PMT

Calibration Method

Conversion Parameter

- Conv. para.from ADC to p.e.
  - Our PMT has one p.e. resolution. (see right figure)
  - Fit the 1 p.e. peak by gaussian.

We calibrate ACC
by using physics data.



Zero-Suppressed data

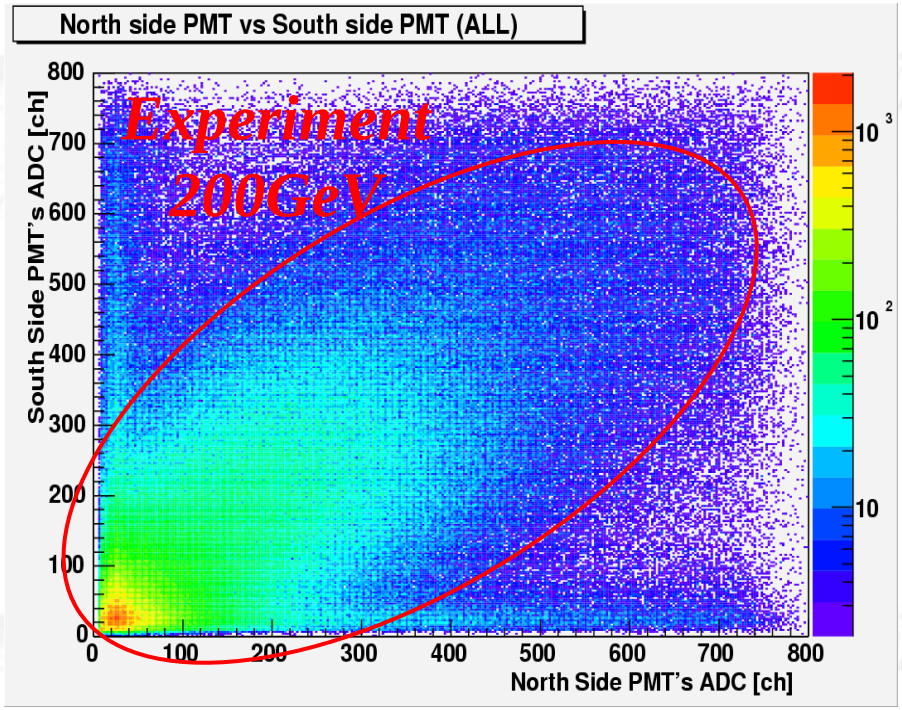
Pedestal Stability

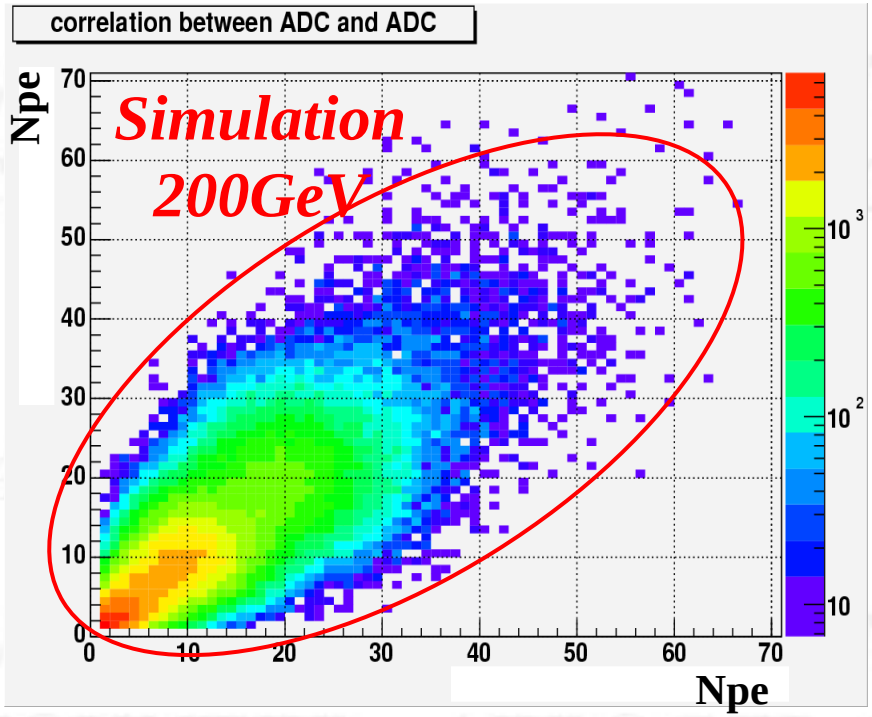
- We took pedestal run once on a day.

We check pedestal stability
by using daily pedestal run.

Results @ Run4 Au+Au

(I) Raw data



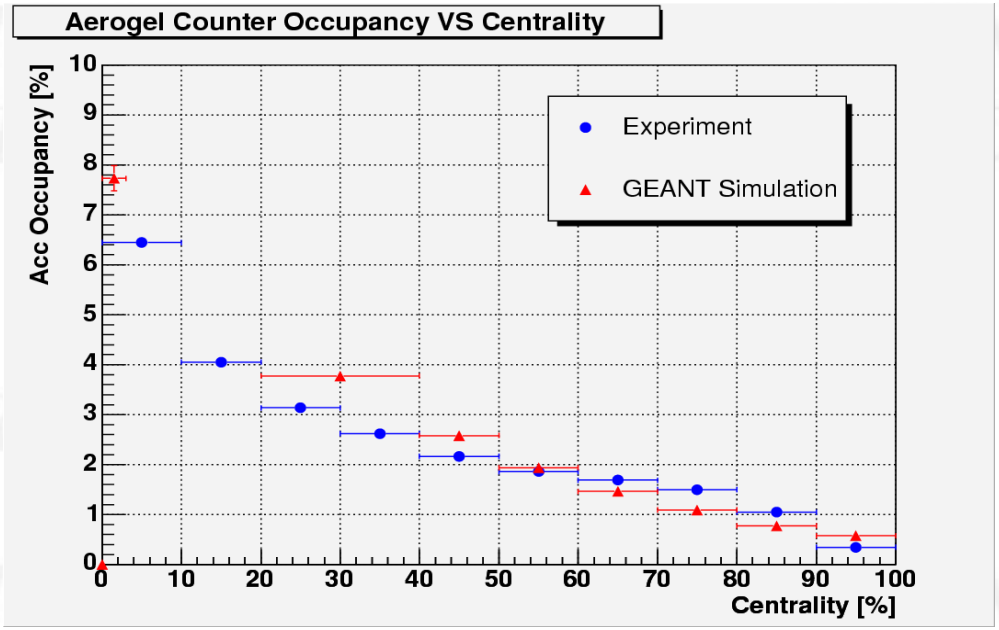


- we can see the coincidence data clearly.
- Aerogel Counter works well !!

Results @ Run4 Au+Au

(II) Occupancy

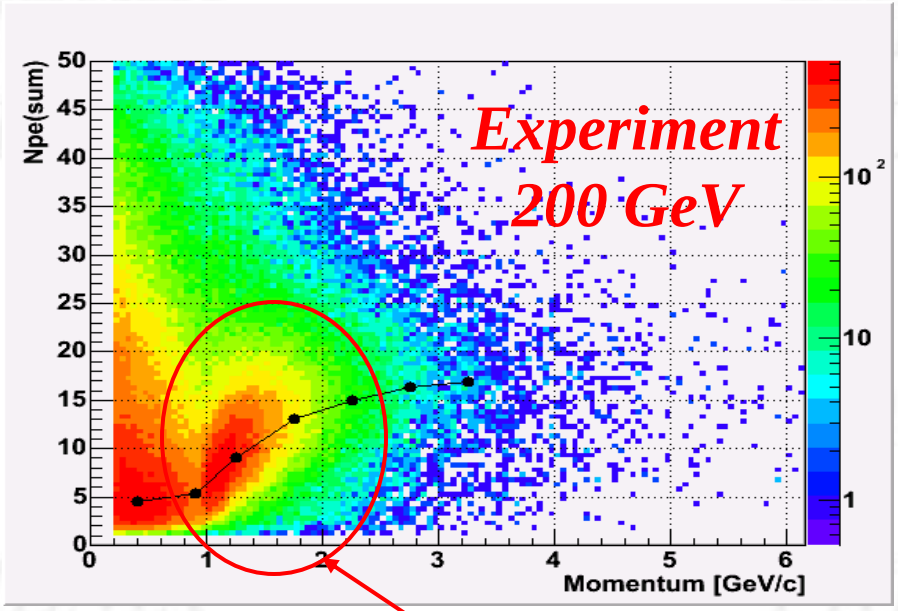
- Simulation
  - calculated by PISA
    - HIJING Au+Au 200 GeV
- Experiment
  - Run4 Au+Au 200 GeV

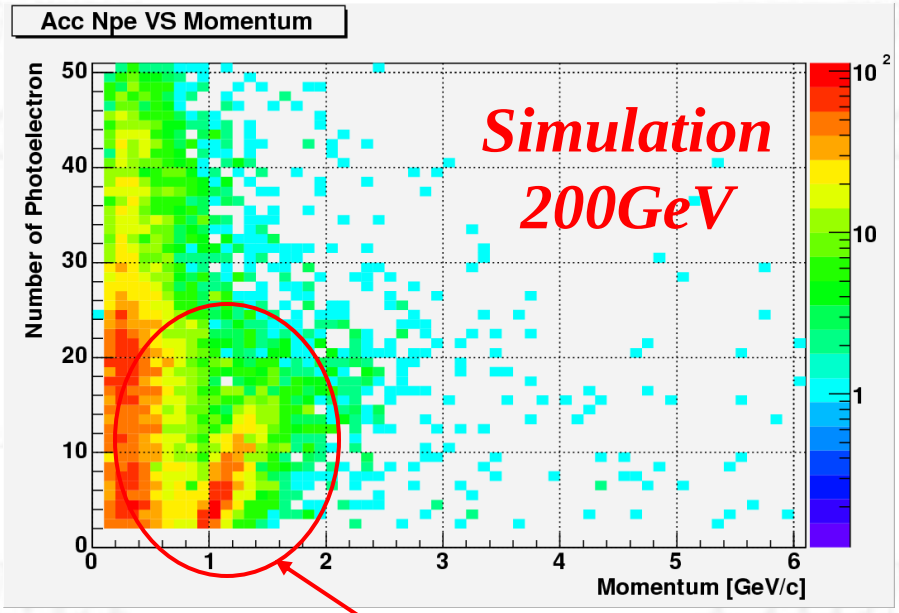


Simulation result is consistent with experimental result !!

Results @ Run4 Au+Au

(III) Tracking association

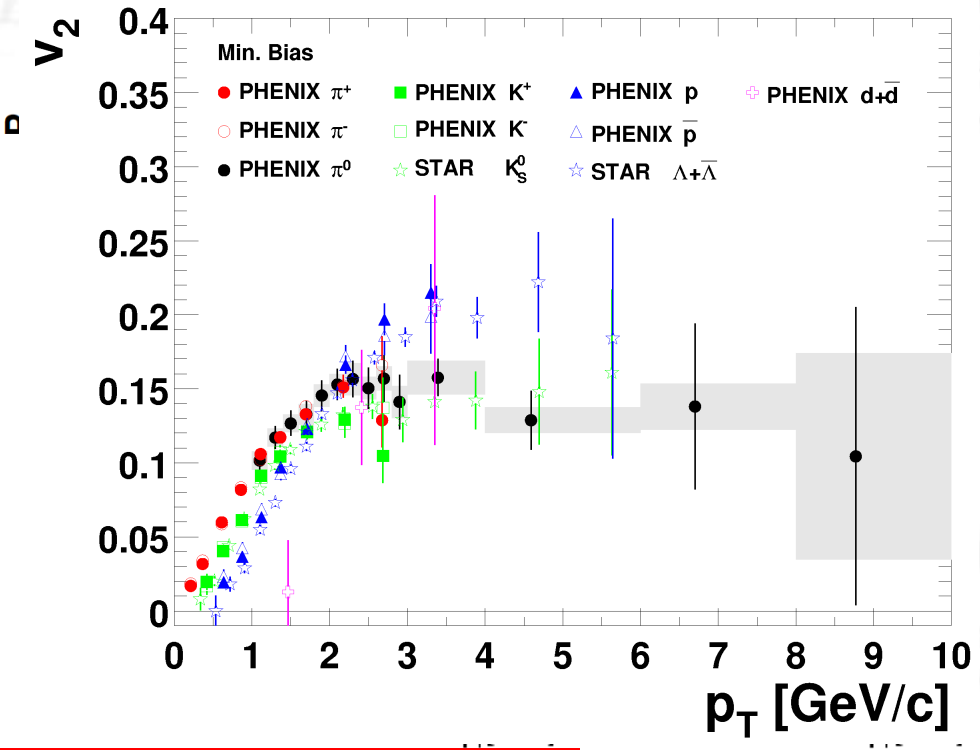




- Clear pion rise up to ~ 2GeV/c. (K, p not seen.)
- Peak position of Npe saturates at high momentum region.

Physics Results (future plan)

- Single particle p_T spectra
- Central-to-Peripheral ratio(R_{cp}) vs p_T
- Elliptic Flow
- etc…



In near future, the analysis results will be presented

Summary

- ✓ Half the detector has been installed in Run4.
  - remaining half detector will be installed by Run5.
  - New Time-of-Flight will be installed behind the Aerogel.
- ✓ The PHENIX Aerogel-Cherenkov-Counter is capable to extend the PID region of PHENIX.
  - pion identification : ~ 3.7GeV/c, 5.5GeV/c ~ 10GeV/c
  - kaon identification : ~ 3.7GeV/c, 5.5GeV/c ~ 7GeV/c
  - proton identification : ~ 7GeV/c
- ✓ In near future, the physics results will be presented.
  - example
    - Inclusive particle p_T spectra
    - Central-to-Peripheral ratio (R_{cp}) vs. p_T
    - Elliptic Flow
    - etc

Institutions

- ✓ BNL
- ✓ JINR-LHE (Dubna)
- ✓ CNS, University of Tokyo
- ✓ Tsukuba College of Technology
- ✓ University of Tsukuba

And, of course, much more people are related to the past/coming successful construction/operation of it.

Lots of persons for the essential works in the past, and much more persons in the future.